Stefano Redaelli, 16-02-2009

97th Meeting of the LHC Collimation Working Group, December 17th, 2008

Present: Ralph Assmann (chairman), Giulia Bellodi, Dariusz Bocian, Till Tobias Bohlen, Chiara Bracco, Fritz Caspers, Bernd Dehning, Hitomi Ikeda, John Jowett, Luisella Lari, Stefano Redaelli (scientific secretary), Stefan Roesler, Adriana Rossi, Mariusz Sapinski, George Smirnov, Eric Veyrunes, Thomas Weiler.

Comments to the minutes and follow-up of actions

No comments to the previous minutes.

Follow-up of open actions:

- R. Assmann and S. Redaelli had preliminary discussions with V. Baglin about the installation of additional temperature sensors in IR3 and IR7. A proposal for the new layout will be presented here by the AT-VAC team.

Agenda of this meeting

- Highlights of 2008 collimator beam tests at the SPS (S. Redaelli).
- Beam loss patterns at the LHC collimators (T. Boehlen)
- BLM thresholds for the LHC collimators (M. Sapinski)

List of actions from this meeting

Action	People	Deadline
Feasibility of bunch-by-bunch BLM gating for the LHC monitors of the transfer line collimators	BLM team	asap
Review settings of collimator BLM thresholds	Collimation +BLM teams	Before 2009 op.
Schottky pick-up to measure off-bucket beam properties?	F. Caspers	asap

(Complete list at http://lhc-collimation.web.cern.ch/lhc-collimation/action.htm)

The next meeting will be announced.
Provisional agenda: **http://lhc-collimation.web.cern.ch/lhc-collimation/**

Minutes of the meeting

1 A.O.B

- The **shut-down activity** for the completion of the Phase I installation is ongoing. This activity is followed-up by the Collimation Production Steering meeting within the general coordination of the LHC-WC teams.

- The **SPS collimator prototype** will remain in the SPS-SS5 as it is (no upgrades of hardware and software). The possibility of replacing the existing collimator with another prototype with integrated BPM's was considered. However, it was decided that these advanced tests will take place in 2010.

- In the framework of the discussions about the **future of the AB committees**, R. Assmann asked feedback on whether the LHC collimation Working Group should be continued or discontinued. There was a general agreement of the various parts represented at this meeting (ABP, ATB, BI, OP) that this forum does not duplicate other existing forums and it will have an important role for the commissioning. It should therefore be maintained in the future. R. Assmann will transmit to the managment this outcome as an input for the re-organization.

2 Highlights of 2008 collimator beam tests at the SPS (S. Redaelli)

S. Redaelli presented the outline of the 2008 collimator beam tests at the SPS:

1) Beam loss studies and BLM signal calibration with injected beams at 26 GeV.

2) Collimation studies with coasting beam at 270 GeV.

Since the first item was going to be covered by T. Boehlen (see next section), Stefano focused his presentation on the collimation studies with coasting beam, which involved (1) collimator beam-based alignment; (2) angle adjustment; (3) beam lifetime studies for different collimator settings; (4) effect of RF voltage on loss patterns; (5) fast beam loss acquisition studies. The MD was carried out with LHC-type beams made of 12 bunches (25 ns spacing) of about 5×10^{10} p, with normalized emittance of about 1.5 μm, corresponding to an horizontal beam size at the collimator of ≈ 350 μm.
Details of the measurements and preliminary analysis results can be found in S. Redaelli's slides. New observations carried out this year, namely on effects related to the **beam losses and lifetime as a function of collimator settings** and on the contribution of **off-bucked particles** to the beam loss profiles, were mainly discussed.

As suggested by experiments done at the Tevatron (at the end of October R. Assmann, V. Previtali and S. Redaelli participated to a crystal beam experiment carried out at the Tevatron), the particles that are outside the RF buckets show a very different behaviour than the captured beam. At the Tevatron the observation of this effect is done by gating the BLM acquisition on empty of full buckets (D. Still, priv. comm.). The different behaviour of un-bunched beam was also confirmed at the SPS by looking at the difference between bunched and un-bunched beam lifetime. On the other hand, no direct beam loss measurements are possible because the BLM integration time of 20ms does not allow bunch-to-bunch gating. This will also be the case for the LHC. It was **proposed** that we should look into the possibility of **upgrading the LHC BLM system** in order to distinguish between the two types of beams.

F. Caspers commented that we could see signals gated on the LHC abort gap with the 3 GHz **Schottky monitor**. This possibility should be also be looked into.

S. Redaelli also showed that if the collimator jaw is placed close to the beam, the **beam lifetime** is significantly **reduced** (see plot at page 13). R. Assmann commented that the results of lifetime versus collimator setting cannot be easily extrapolated from the SPS case to the LHC case. He also reminded that the experience on the SPPS operation showed that the machine could be operated with collimator settings of 5 sigmas and below without significant lifetime limitation. Clearly this effects needs further investigation.

3 Beam loss patterns at the LHC collimators (T. Boehlen)

Till Tobias Böhlen presented comparison of simulations and measurements of beam losses at the SPS and predictions for the LHC. The data collected during SPS beam tests are used to benchmark the simulations (a dedicated FLUKA model has been developed to match the SPS collimator layout). Simulations are then used to calculate the BLM response function for the LHC configuration. This work was carried out as part of Till's diploma thesis, which is now available in the CERN thesis repository as document CERN-THESIS-2008-092. Details of Till's work should be looked at in this document and in his slides.

The comparison between measurements and simulations for the SPS case show errors of the order of 10-20 % for the prediction of absolute signal of the ionization chambers. Errors for the SEM monitors are up to a factor 3-4 worst. Simulations for the case of direct beam impact on the collimator are more accurate than for the case of continuous beam scraping.

T. Böhlen then showed the results of detailed LHC simulations of energy deposition studies and cross talk between monitors. Jaw roughness, flatness and tilt angle are taken into account in simulations. Till studies the sensitivity of BLM signal on various sources of errors. For example, a 20% change of BLM signal is expected if the monitor is moved by 3 cm. R. Assmann commented that this is very sensitive! Details of all simulations results are shown in pages 10 to 13 of Till's slides.

B. Dehning stressed the importance of the plots at p. 12 that show how the energy in deposited in the collimator and energy deposited in the BLM are constant for large ranges of impact parameters (pencil beam is assumed) and for various beam sizes. **Collimator heating does not depend significantly on the impact parameter** in a broad parameter range and this relaxes the constrains on the definition of BLM thresholds.

S. Redaelli commented that the **BLM signals differ by about 40%** for **horizontal** and **vertical collimators**. On the other hand, the first SPS beam tests in 2004, done with 4 monitors around beam pipe, indicated symmetric response of monitors in different location. Is this discrepancy understood? B. Dehning replied that the difference is not clear but for LHC the ionization chamber is further away from the beam than in the configuration tested at the SPS.

The peak energy in the collimator was also calculated with input from A. Alonso, who simulated loss distributions for various magnet failure scenarios. For short losses, B. Dehning believes that we need to decrease the BLM thresholds in order to be able to catch early fast failure scenarios. A **factor 10** seems reasonable. R. Assmann commented that the collimator protection would not be compromised in case of fast losses (high steady losses more dangerous). We have to decide if we want to set thresholds in order to protect the machine for these cases.

As a conclusive remark, R. Assmann warned that for next tests we should be careful in sending too much beam on the collimator: at low energy the beam size is bigger and we could more easily hit the metal cooling pipes.

4 BLM thresholds for the LHC collimators (M. Sapinski)

Mariusz Sapinski presented the values of BLM thresholds for collimator protection (thresholds are available so far only for proton operation). The thresholds for all the integration times and the scaling against beam energy are calculated from the input table of maximum allowed proton loss rates provided by R. Assmann. It is noted that these inputs used a safety factor 10 at injection energy and no safety factor at 7 TeV.
The calculation takes into account the energy deposited in the BLM per proton lost in the collimator, as calculated by T. Boehlen (see previous talk) and the corrections for fast failures scenarios according to the simulations of A. Gomez Alonso (used to infer the number of lost protons per turn). For the moment, the scaling with energy is linear and for the results given did not include any safety factor. In addition, M. Sapinski reminded that the measurements done during the LHC beam commissioning showed that the fast BLM integration times below 10 ms underestimate the real losses. This systematic effect is also taken into account.

M. Sapinski showed examples of the threshold functions calculated for the TCP's. Clearly the contribution of some effects like the higher-order halos and the peak energy for fast losses need refinements. On the other hand, the algorithm to calculate the collimator thresholds while taking into account all the effects mentioned above is well established and is ready to be used to generate the thresholds for the 2009 beam operation.
From M. Sapinski's results it appears that in some cases the protection thresholds for the collimators (calculated by taking into account several safety margins, as discussed in Mariusz' presentation) are only a factor 70 higher that than the thresholds that protect against quenches of superconducting magnets. He suggested that the detailed implementation of the collimator thresholds should be reviewed off-line in order to prepare a consistent set of settings for the 2009 operation.

The next meeting will be announced.